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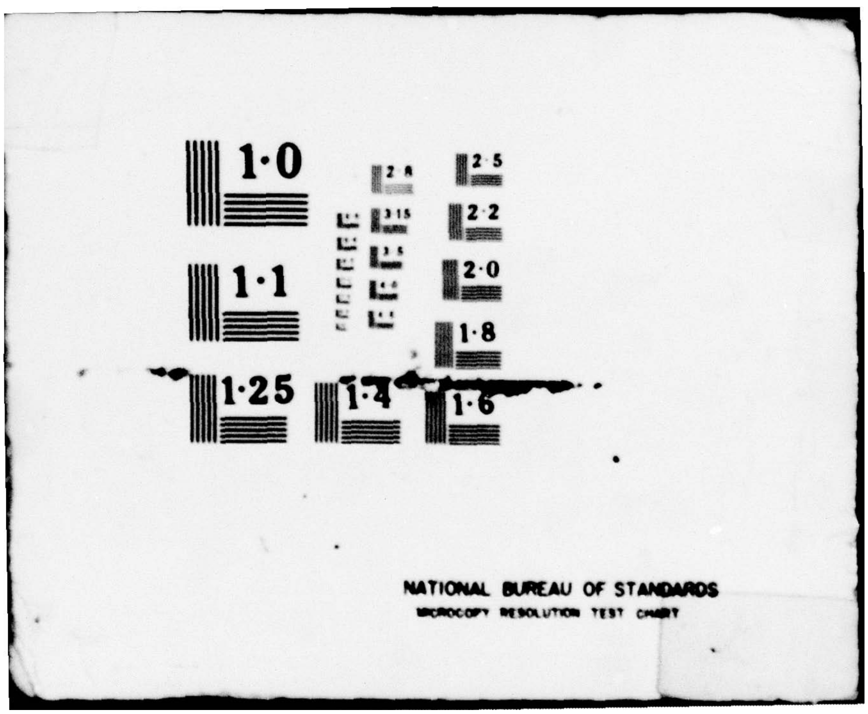
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(12) LEVEL III

IDA STUDY S-504

IMPLEMENTING USAGE-SENSITIVE CHARGES FOR AUTODIN

VOLUME I: Basic Study

James P. Bell
John N. Fry
Dale L. Moody

November 1978

Prepared for
Defense Communications Agency

INSTITUTE FOR DEFENSE ANALYSES
PROGRAM ANALYSIS DIVISION

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A technique is developed for accumulating and processing data on AUTODIN digital communication usage, applying usage rates and computing user charges for billing purposes. The program was activated on Defense Commercial Communications Office computers and tested using a special 1978 sample of actual system traffic and several alternate rate structures. Resulting cost distributions are shown and discussed. The problems of system implementation and interpretation of data are discussed.

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I. INTRODUCTION AND SUMMARY

This study is the second report on research into financial management aspects of the common user communication systems under Defense Communications Agency (DCA) administrative control. The two principal systems in terms of financial impact are AUTODIN (Automatic Digital Network) and AUTOVON (Automatic Voice Network). The first is a world-wide digital store-and-forward system[1] for data and message transmission. The second is a world-wide telephone system linking defense establishments via an automatic switching network. In a previous IDA study,[2] recommendations for changing the cost allocation methodology for AUTODIN were made. In the present study the feasibility of implementing such a methodology is investigated. For the latter purpose, DCA provided the study group with a sample of 1978 AUTODIN usage information and access to the offices and personnel who would have responsibility for implementing the recommended usage-sensitive cost allocation. IDA was requested to provide:

(1) A computer model of a billing system for implementing usage-sensitive cost allocation and appropriate documentation to enable DCA to program its AUTODIN switches to obtain the required data.

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[1]Messages and data entering the system at switching centers are accumulated and, when a circuit is available, dispatched (processing times and delay times are typically in seconds or minutes) to the destination switch where the information is again stored to be later delivered to the addressee's terminal. This is "message" switching as compared to "circuit" switching in which two communicators, as in telephone, must be connected by a real-time circuit for communication to take place.

[2]W. Beazer, L. Davidson, J. Fry, J. Kiernan, and W. Raduchel, *Cost Allocation for AUTODIN: An Economic Analysis*, IDA Study S-487, Institute for Defense Analyses, Arlington, Va., 1977.

(2) Results of tests of such a model on IDA computers.

(3) Comments on the use of the billing methodology specifying limitations and directing attention to areas of concern for DCA in planning for future services.

The detailed specifications of the IDA computerized cost-allocation model are contained in the technical Appendices A through D. The model is also described in general terms in the text. The requirement of appropriate documentation was further met when a version of the IDA model was tested at the computer facilities currently used for billing at the Defense Commercial Communications Office (DECCO) at Scott Air Force Base, Illinois. The authors verified that the DECCO version produced identical results to IDA's version when the same sample of data was analyzed.

The results of applying the IDA cost-allocation model to the sample data are discussed below. This descriptive material provides insight into the kinds of analyses which can be performed using data available in the present AUTODIN system. In addition, it places the planning and budgeting problems inherent in usage-sensitive costing in perspective.

The final section of the study discusses the problems of implementing the cost-allocation methodology and proposes some immediate steps to solve those problems.

In summary, the study conclusions are:

- The information necessary to allocate AUTODIN backbone costs on a usage basis exists within the AUTODIN system and can be collected and processed.
- No substantial addition of equipment or personnel is required to compute and disseminate bills based upon relative usage.
- Predicting the response of users to cost-allocation changes arising from usage costing may be difficult for the first year of implementation, but should be easier as empirical data are developed.

The study recommendations are:

- The cost-allocation/billing program developed in the study is suitable for activation as a data-gathering program or billing system.

- The data base produced by the billing program can be used to develop baseline data for studies of user response to the usage-sensitive pricing changes and of user system changes.

- DCA should take into account the need to minimize the likelihood that use of usage-sensitive pricing for equitable cost allocation purposes could lead to responses by users that reduce network efficiency either in an economic sense or in the sense of compromising crisis C^3 response capability.

II. THE AUTODIN SYSTEM

The Defense Communications Agency is required to recover outlays made from its Communications Services Industrial Fund (CSIF) for the so-called AUTODIN "backbone" from charges levied upon the agencies and activities which use the system for sending defense-related messages and data among themselves. Figure 1 gives a schematic representation of the so-called "backbone," that is, the switching centers and trunks whose cost is to be recovered from charges levied against the appropriations of the using agencies. These costs consist of outlays for the leasing of switches and trunks from private communications companies in the United States and abroad, as well as from government agencies such as the General Post Office in Britain and Deutsches Bundespost in Germany. In addition, reimbursements to the Services for some operations and maintenance of government-owned switches are made by DCA. Table 1 below summarizes some of the detail for recent fiscal years. In the remainder of the study, we have simplified and combined cost categories for illustrative purposes.[1]

The physical network shown in Figure 1 serves a community of defense-related activities spread over some 30 agencies, from the major services (Army, Navy, Air Force) through the Defense Intelligence Agency, the State Department, the Federal Aviation Agency, to the Smithsonian and the Red Cross.[2]

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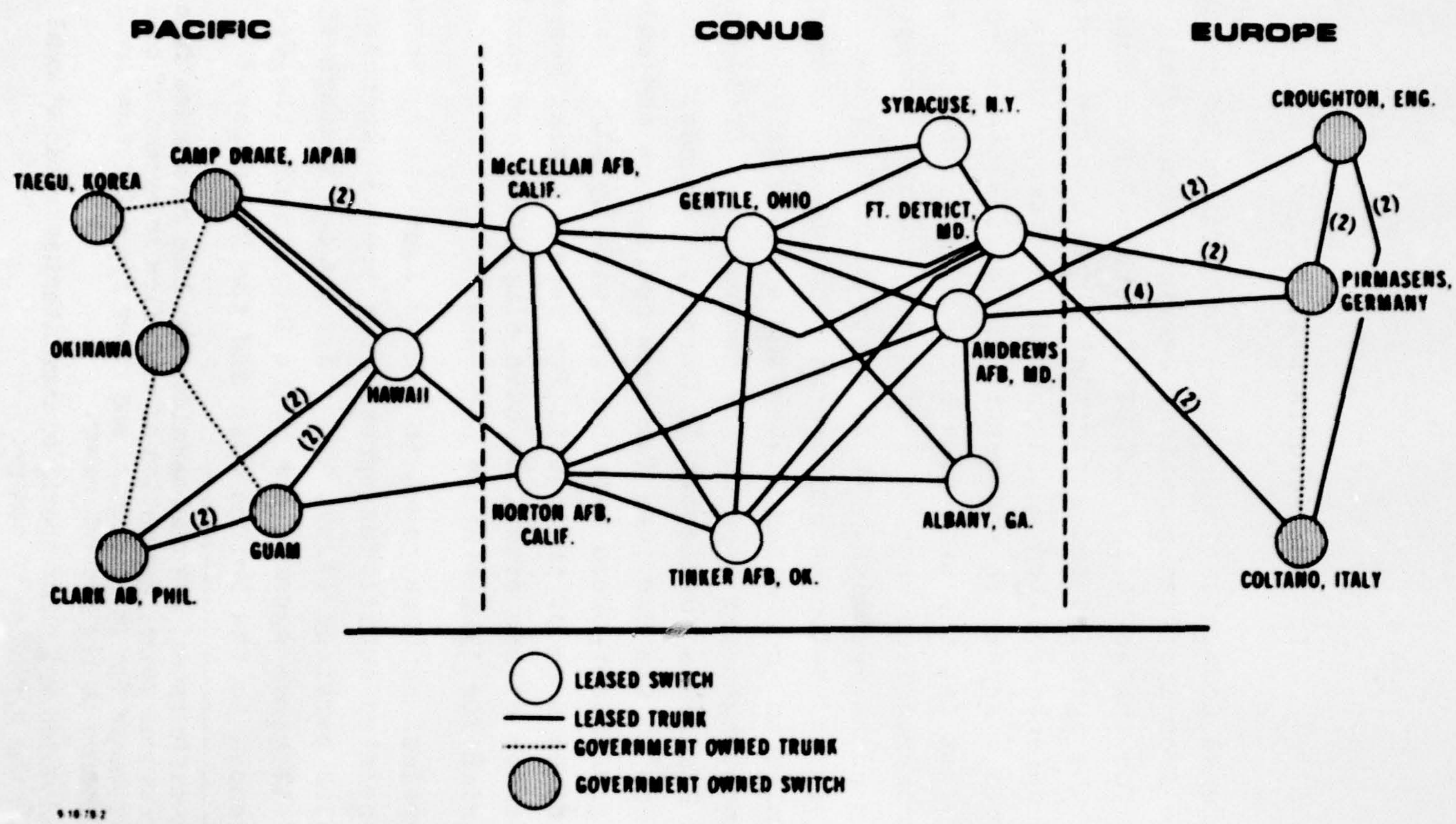
[1] In setting specific rat[illegible] DCA must consider the loss recoveries from undercharging in previous years, generation of cash flow in excess of outlays to cover prepayments for improvements, and other financial flow problems of little relevance to the present paper.

[2] Red Cross activities and other specified humanitarian or educational activities use the system at no charge.



Adapted from DCA reports. The OKINAWA switch is presently on inactive status.

Figure 1. AUTODIN SYSTEM (AS OF FY 1977)

Table 1. DEFENSE COMMUNICATIONS AGENCY COMMUNICATIONS SERVICES INDUSTRIAL FUND

AUTODIN I BACKBONE PROGRAM AND EXPENSES
(Dollars in Thousands)

DESCRIPTION	FY 1977 - ESTIMATE NUMBER	FY 1977 - ESTIMATE COSTS	FY 1978 - ESTIMATE NUMBER	FY 1978 - ESTIMATE COSTS
PROGRAM DATA				
NUMBER OF OPERATIONAL SWITCHES (E/Y)				
CONUS	8	XXX	8	XXX
OVERSEAS (INCLUDES HAWAII)	9	XXX	9	XXX
EXPENSES				
SWITCHING CENTERS:				
LEASED SWITCHES		$29,630		$32,132
AMORTIZATION		718		730
O&M OF SWITCHING CENTERS		12,261		13,470
DEPOT MAINTENANCE (OVERSEAS)		380		420
OTHER AND NON-RECURRING		203		215
TOTAL SWITCHING CENTERS		$43,192		$46,967
TRUNKS:				
CONUS (Leased)	19	$356	19	$378
Europe (Channel Pack)	14	740	16	880
Pacific (Leased)	4	470	4	498
Pacific (Channel Pack)	8	560	8	594
TOTAL TRUNKS	45	$2,126	47	$2,350
AUTOVON INTERCONNECTS:				
Connection Costs		$81		$85
AUTOVON Subscriber Rates		1,216		1,081
TOTAL AUTOVON INTERCONNECTS		$1,297		$1,166
OVERHEAD		460		742
TOTAL AUTODIN BACKBONE EXPENSE		$47,075		$51,225

Table 2 below summarizes the hierarchy of user elements. Currently the AUTODIN "backbone" costs are recovered from the budgets of the program budget elements controlling the "access" lines. These access lines are commercial or government-owned communications lines physically connecting a terminal, identified for DCA by a Program Designator Code (PDC), which has a budget allocation from its agency appropriations to cover communications services supplied by the AUTODIN network.

Table 2. USER STRUCTURE

Element	Number	(DCA Identifier)
Agencies	30	
Budgetary Activities (Cost Centers)	350	(PDC)
Access Lines (Costed Element)	1300-1500	(CCSD)
Commands and Units (AUTODIN Address)	5000-6000	(OSRI)
Message Senders	?	

Beyond the access line terminal, which may be (among other arrangements) a computer, a switchboard, a series of teletype extensions, or a message center like a telegraph office, there is the changing community of some 1500 or so Originating Stations which have Routing Indicators (OSRI) in the switching programs. That is, they are known to DCA as addresses to which messages and data may be automatically delivered via the AUTODIN network. These OSRIs are a heterogeneous group; some are units of organizations--say, the Joint Chiefs of Staff, or the *U.S.S. ENTERPRISE*, or the Army Forces Command--others are switchboards or message centers at army posts or air bases. The one thing that is not true is that the agency budget affiliation for say, personnel purposes, is always the same for an OSRI as

it is for the PDC which pays for AUTODIN. In Washington, for instance, the U.S. Army budgets for Pentagon AUTODIN communications links that service the whole spectrum of Defense activities. It is even more complex at the next level below the OSRI. When one gets downto the specific individuals and offices who are authorized to approve use of AUTODIN, one may find a Navy Captain housed on an Air Force facility that is connected to an Army terminal for AUTODIN services.

The Albany, Georgia AUTODIN switching center, as an example, is connected to AUTODIN trunk lines to the AUTODIN switching centers at Norton Air Force Base, California, Gentile, Ohio, and Andrews Air Force Base, Maryland. From that Albany switch, however, there were in the 1978 sample some 101 access lines branching out to DoD facilities in Georgia, Florida, the Carolinas and elsewhere, serving at least 187 different addresses. Table 3 summarizes the distribution among agencies.

Table 3. AN AUTODIN SWITCH USER CONFIGURATION: ALBANY, GEORGIA ASC

AGENCY WITH BUDGET (PDC) RESPONSIBILITY	NUMBER OF ACCESS LINES	NUMBER OF ADDRESSEES (OSRI)
Army	30	84
Navy	37	49
Air Force	26	42
Defense Logistics Agency	4	8
Federal Aviation Agency	3	3
National Aeronautics and Space Agency	1	1
TOTAL	101[a]	187

[a]Of the 101 lines, 11 were high speed, 36 medium, and 54 low speed.

As we shall see later, the rationale for AUTODIN cost allocation as developed by IDA Study S-487[1] does not currently require that usage be identified down to the individual or organization that *decides* to use AUTODIN. In ordinary economic terms, the element whose purpose is served by communications is the beneficiary of the service, the *causer* of the cost if such a use involves a marginal cost. The Defense Communications Agency, however, requested that IDA demonstrate a system with the *capability* to identify usage with user down to the OSRI level in case it was desired to bill on a current basis (at least monthly) for usage. While our recommendation is that DCA *not* bill thusly for AUTODIN on a current usage basis, the capability to trace usage on a current basis to originators is not only likely to be required for billing for future common-user services, but also provides information to managers useful in planning and forecasting.

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[1]Beazer, *et al*, *loc. cit.*

III. CURRENT DCA RATE AND BILLING PRACTICE

At the present time, DCA provides services to the "access" lines and looks to the "owner" of the access line to pay monthly charges destined to recover AUTODIN backbone costs. Table 2 tells us that the access line is owned by a program package entity called a PDC, which is funded from the budget of one of 30 agencies of the U.S. Government. The Air Force, Army, Navy, Defense Logistics Agency, and FAA constitute the principal agencies paying for access lines.

The Defense Communications Agency, through its agent, the Defense Commercial Communication Office (DECCO), pays (usually monthly) for all sorts of communications services furnished both to DCA and to the customer agencies. Payment is made out of its Communications Services Industrial Fund (a revolving fund); in turn, it replenishes the fund by billing the agency appropriation accounts for communications. At present the AUTODIN "bill" for each access line connection to the switch network is calculated to recover overall backbone costs by a charge varying with the "speed of service," that is, the transmission rate (in bits per second) of the access line. The three basic classes--"high", "medium" and "low"--pay monthly charges in the ratio of 14:9:3.

This ratio is based upon the relative amount of computer memory assigned to each type of line in the Accumulation and Distribution Unit (ADU) of the leased Automatic Switching Center. This unit coordinates the receipt and dispatch of signals with the internal processing by the computers that manage the switching and store-and-forward functions. The present assignments are: 28 line-blocks to high speed (2400 bits/second and above); 18

line-blocks to medium speed (600 to 1200 bits/second); and 6 to low speed (under 300 bits/second). Table 4, taken from a more extensive DCA listing, shows some recent proposed rates.

Much simplified, the basis of the current rate structure is determined by multiplying the line speed weights times the planned number of months of hook-up time times the number of various types of lines and dividing the resulting total into the total backbone cost for the budget year. This gives a "cost per weighted unit." Then the budget request for each agency is simply the agency's number of weighted units (as revealed by its planned access lines) times the weighted unit value. Each month the Defense Communications Agency pays Western Union, AT&T, Deutsche Bundespost and other carriers for AUTODIN switch and trunk leases. In turn, based upon actual access line hook-ups, DCA bills each agency for the number of weighted units times the rate. That sum is then transferred from agency appropriations to DCA's industrial fund account.[1] Figure 2 is a portion of one kind of accounting statement which DECCO currently provides for each account.

The actual bill, which requests transfers from the user's appropriations to DCA's CSIF account, is a single value per period for each PDC and includes other communications charges. Such reports as that above are essentially memorandum material. The user charge and connectivity charge under the *proposed* rate structure would be combined in the "bill" to provide a similar number for each PDC. The detailed basis of the charge would be

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[1]Mileage charges for access lines and other off-network communications charges are paid for by DCA, but merely as an agent for the using agencies. These services are contracted for and controlled by the using agencies and budgeted for separately from backbone charges. While DCA's AUTODIN managers are active participants in the planning for AUTODIN "backbone" services and promulgate the "rates" which are designed to cover backbone costs, the planning for off-network communications beyond the access lines is the exclusive province of each agency's communications planner and SECDEF budget managers rather than the DCA comptroller.

provided in the form of a memorandum listing for each paying PDC, showing the sending volume and equivalent charge for each OSRI using a given CCSD (Acess Line).

Table 4. AUTODIN SUBSCRIBERS FY 1978 BILLING RATES

EFFECTIVE 1 OCTOBER 1977			
TYPE OF SERVICE	WTD[a] UNITS	SR[b] CODE	RATE
4800 Baud MSU	14	DL	$9,100
2400 Baud MSU	14	DA	9,100
1200 Baud MSU	9	DC	5,850
600 Baud MSU	9	DN	5,850
300 Baud MSU	3	DE	1,950
150 Baud MSU	3	DG	1,950
Teletypewriter	3	DJ	1,950
Equipment Only	0	DY	0
On Base Extension	0	DZ	0
Monthly Rate Per Weighted Unit			$ 650

[a]WTD = "weighted".
[b]SR = Subscriber Rate.

DETAIL LISTING OF AUTODIN RATE APPLICATION
ACCOUNT CODE AIR FORCE

PDC	TELCO	PRE	TYPE	CIR NR	SUF	CUR MO ADJ	CUR MO CHGS	TOTAL	S-RATE
AAA1[a]	USAF	OC		11000[b]	094	.00	1,950.00[c]	1,950.00	DJ
AAA1	USAF	OC		11000	125	.00	1,950.00	1,950.00	DG
AAA1	USAF	OC		11003	156	.00	1,950.00	1,950.00	DG
AAA1	USAF	OC		11005	023	.00	1,950.00	1,950.00	DJ
AAA1	USAF	OC		11008	072	.00	1,950.00	1,950.00	DJ
AAA1	WU		Q	10057	HAW	.00	5,850.00	5,850.00	DN
AAA1	WU II		D	00109[b]		.00	1,950.00	1,950.00	DE
PDC TOTALS						.00	17,550.00	17,550.00[d]	
AAA2	USA	--	--	--	--	--	--	--	--
AA--	--	--	--	--	--	--	--	--	--
A--	--	--	--	--	--	--	--	--	--

[a] PDC: AA1 is the Pacific Air Force-DSSC network.

[b] This item is the Communications Service Authorization (CSA) number, which grants authority to a user to connect to AUTODIN via an access line. It identifies the access line uniquely. The first is owned by the Air Force, the last by Western Union.

[c] Connectivity Charge: We know from reference to the S-Rate (Subscriber rate) and another listing that this is a teletype terminal, or low speed connection, for which the current connectivity charge is $1,950 per month.

[d] This would be the amount transferred from Air Force appropriations to SCIF for PDC AA1's account for the month.

Figure 2. FACSIMILE OF DECCO ACCOUNTING STATEMENT

IV. ANALYSIS OF USAGE PATTERNS

In the process of preparing the sample usage data for the cost-allocation step, a number of characteristics of the system which could be of significance to the estimation problems discussed later were noted. During the one week sample period, for instance, AUTODIN users originated 2,079,552 separate transmissions, amounting to a total of 80,871,403 line blocks.[1] The seven day sample of 1976 data used in IDA Study S-487, for comparison, showed 1,973,212 messages and 78,435,145 line blocks. The present sample shows increases of five percent in messages and three percent in line blocks. These figures are certainly consistent with the observed stability in the size of the Defense establishment over this period. The figures also give some assurance that the 1978 sample is not anomalous, but probably typical of overall volume at least.[2]

The pattern of traffic can be derived from switch-to-switch line block and message matrices such as Figure 3, which is one kind of output that can be provided for analysis in the data program. Utilizing the three-fold definition of traffic types for rate purposes and these data, we can display the way usage

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[1] A line block is a measure of message volume, equivalent to 84 characters, or about one computer card of data. Header extracts for portions of three switches on one day and one switch on another day were missing from the sample. An estimate of the volume of missing data gave about 0.2 percent of the total. No effort was made to adjust for missing data. It was assumed that the sample variability was probably larger than this amount.

[2] Because of different processing techniques, a full comparison of the distributions of AUTODIN traffic as seen in the 1976 and 1978 samples could not be made. For the PDC codes that could be identified, volumes were extremely variable between the two samples, showing no particular pattern.

NUMBER OF LINE BLOCKS--TOTAL   7 DAYS ENDING WITH RADAY 10 OF YEAR 1978

FROM/TO	RUEA	RUCL	RUHH	RUEO	RUDO	RUMJ	RUCI	RUEO	RUAS	RUWW	RJWJ	RUFT
RUEA	3696051	961850	92626	920128	990692	167040	633167	557537	232853	671762	664262	354800
RUCL	843546	1782967	60189	787932	180773	38074	892366	492479	30132	239190	629666	165591
RUHH	21034	49725	224176	80003	50257	139142	24986	41620	99190	28191	104171	7299
RUEA	979925	1361672	177116	3847076	877988	72702	961270	926196	311136	656616	647705	470770
RUDA	781099	99680	14800	160281	912285	13100	89760	85443	28783	44796	48780	530336
RUMJ	48660	30524	158053	47700	10076	232399	41670	40720	84072	71007	70597	6639
RUCI	338097	793979	24669	566207	129927	27378	1363567	669272	62719	253147	1231314	191919
RUEO	392481	995327	82971	720122	200407	60054	822810	1613270	52612	321532	728256	299832
RUAN	167011	59533	137071	73914	3476	43896	56823	18199	538210	85367	54062	2367
RUWW	299049	364714	89393	460020	22081	80799	402083	272600	82999	1211380	643180	22103
RUWJ	393913	647204	109578	401020	73958	241265	822157	309683	110101	593575	1261917	289095
RUFT	401545	119519	2871	460209	410077	4920	196299	186869	7546	32233	81060	990266
RUFL	171089	76721	4211	470346	972365	1997	120936	868910	4433	24348	50204	650246
RUAK	18658	11480	24200	43761	885	2098	17564	30619	74985	24442	67444	962
RUWT	782286	839794	94222	681336	283295	64020	1072831	869663	83076	1033761	960731	309097
RUHH	157422	102067	363453	250227	10950	216925	97059	133903	512607	290669	223323	7159
****	71	300	62	79	6	0	15	67	129	12	270	4
TOT	9109371	7698108	1634839	10020052	3922015	1349925	7574953	6341677	2324579	5372693	7237610	4107139

NUMBER OF LINE BLOCKS--TOTAL (CONTINUED)

FROM/TO	RUFL	RUAK	RUWT	RUHH	****	TOTAL
RUEA	207965	85576	914239	173755	0	9760601
RUCL	119800	27937	454583	59952	0	6731091
RUHH	2264	20255	43097	90740	0	1044307
RUEA	794243	211389	683136	243930	0	12891047
RUDA	519711	903	107656	6276	0	3456179
RUMJ	3969	32274	43660	80099	0	1016301
RUCI	145757	30778	952677	62271	0	6629257
RUEO	109160	114459	456133	51077	0	6545299
RUAN	4296	48969	77252	190244	0	1551777
RUWW	46661	39376	361158	131697	0	4477951
RUWJ	190378	69541	419119	162366	0	6210161
RUFT	981933	2144	123812	4355	0	4098342
RUFL	1181366	1385	99976	6079	0	3332126
RUAK	746	325840	34167	66685	0	746764
RUWT	201667	53736	2177411	76961	0	9547653
RUHH	21297	130156	83613	440337	0	3051654
****	1	32	25	43	78	1150
TOT	4513839	1212669	6624920	1850252	78	80871401

[a]Switch identifications are in Figure 8.

Figure 3. PROGRAM PRINTOUT OF SAMPLE TRAFFIC DISTRIBUTION.

is distributed by area and type as in Figure 4. As can be seen, AUTODIN usage within the continental United States might be expected to carry more than half of the cost burdens inasmuch as it constitutes more than half of the traffic.

The data base being used also permitted us to identify the Program Designator Code affiliation of the originators of the traffic in the sample. Table 5 shows how the message and data demand at an annual rate of four billion line blocks is distributed. In terms of identifiable traffic originating in CONUS,[1] the first four agencies, accounting for nearly 98% of the total, are, in order: U.S. Air Force, Defense Logistics Agency, U.S. Army, and U.S. Navy. From the Pacific, the first four agencies, accounting for almost 100%, are: U.S. Navy (77%), Air Force, Defense Communications Agency and Army. From Europe, accounting for about 94%: Army, Air Force, Navy and DCA. The leading users of AUTODIN, considering world-wide volume are:

	% of Total
U.S. Air Force	25.3
U.S. Army	19.9
U.S. Navy	19.0
Defense Logistics Agency	18.3
"Y" Community	11.0

Whatever the rate structure, one would expect these agencies to bear the principal cost. As we shall see, however, it makes a significant difference among them if a larger or smaller share of total cost is recovered via a usage-based charge.

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[1]Data on traffic attributed to "Y,", which is a collective identification for the intelligence community, were stripped of specific OSRI and area descriptions for security reasons before being delivered to IDA. This and some unidentifiable originators accounted for about 14 percent of the sample data. PDC 4WDK is listed as a DCA activity, but apparently is not. Its actual identification is apparently classified. The annual rate is simply the volume times 52.

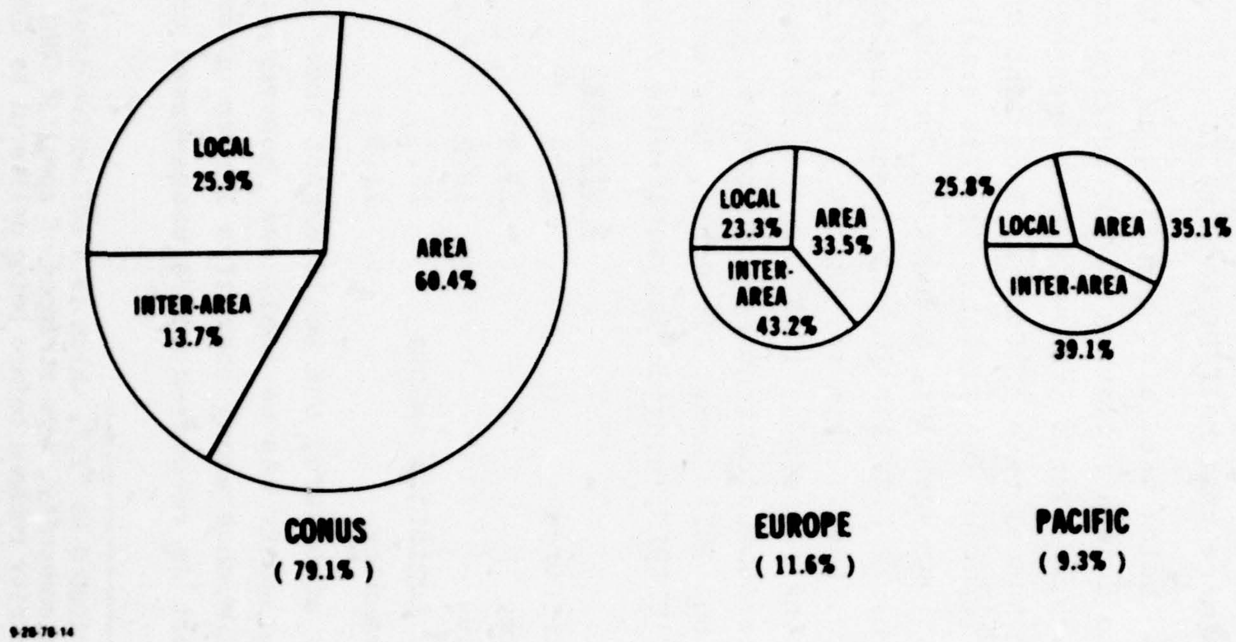

Figure 4. DISTRIBUTION OF AUTODIN TRAFFIC LINE BLOCK MEASURE OF VOLUME (1978 DCA SAMPLE)

Table 5. ESTIMATED ANNUAL AUTODIN TRAFFIC BY AGENCY AND TYPE
(Based on 1978 Seven Day Sample)

AGENCY	AREA OF ORIGIN	TYPE OF TRAFFIC (Line Blocks in 000's)			
		LOCAL	AREA	INTER-AREA	TOTAL
USAF	CONUS	229,414	574,924	119,667	924,005
	PACIFIC	7,047	14,345	25,904	47,296
	EUROPE	25,240	26,512	55,458	107,210
USA	CONUS	192,921	374,410	106,200	673,531
	PACIFIC	13,358	5,449	8,012	26,819
	EUROPE	36,719	67,290	42,152	146,161
USN	CONUS	147,124	255,234	97,750	500,108
	PACIFIC	41,030	78,913	91,292	211,235
	EUROPE	29,221	26,647	40,312	96,180
DLA	CONUS	180,202	538,760	60,057	779,019
DCA (ECBC,EUDK)	CONUS	8,379	9,424	5,245	23,048
	PACIFIC	13,000	8,621	12,476	34,097
	EUROPE	7,062	12,304	5,495	24,861
FAA	CONUS	1,169	1,450	186	2,805
	PACIFIC	108	17	60	185
DNA	CONUS	1,487	2,610	1,831	5,928
ARMED SERV. INFO. OFC.	CONUS	2,213	2,060	8,096	12,369
DMA	CONUS	150	321	44	515
DIA	CONUS	7	346	382	735
NASA	CONUS	36	20	-	56
USIA	PACIFIC	21	36	267	324
GSA	CONUS	239	18,650	937	19,826
NSA	CONUS	276	554	176	1,006
	EUROPE	10	38	37	85
ERDA	CONUS	264	660	101	1,025
US WTHR. SERV.	CONUS	185	127	8	320
SMITHSON.	CONUS	12	12	36	60
JUSTICE	CONUS	194	94	234	522
STATE	EUROPE	1,609	1,722	2,339	5,670
AUDK	EUROPE	2,540	4,794	9,266	16,560
"Y"	(?)	148,648	129,469	193,178	471,295
SUB-TOTAL		1,089,085	2,155,773	887,198	4,132,056
UNIDENT.	(?)	60,683	50,210	15,081	124,974
TOTAL		1,149,748	2,205,983	902,279	4,258,010

RECAPITULATION

AREA OF ORIGIN	TYPE OF TRAFFIC (000's of Line Blocks)			
	LOCAL	AREA	INTER-AREA	TOTAL
CONUS	764,272	1,779,656	400,950	2,944,878
PACIFIC	74,564	107,381	138,011	319,956
EUROPE	102,401	139,267	155,059	396,727
SUB-TOTAL	941,237	2,026,304	694,020	3,661,561
"Y"	148,648	129,469	193,178	471,295
SUB-TOTAL	1,089,085	2,155,773	887,198	4,132,056
UNIDENT.	59,863	50,210	15,081	125,154
TOTAL	1,149,748	2,205,983	902,279	4,258,010

The ability to identify usage with specific originators permits us to examine the degree of concentration of traffic volume. Table 6 shows some data for the top ten users. The predominance of logistics functions is probably understated. While the JCS-attributed traffic (RUEKJCS) may represent command, control and readiness matters, the Air Force Logistics Command and the Defense Logistics Agency originators clearly represent supply and support operations. The Navy practice of tying all users to Naval District accounting codes, versus the functional identification used by Army, Air Force, and other agencies, makes it impossible to distinguish the nature of Navy traffic without additional research into classified sources. Since the 5th Naval District includes the enormous Atlantic supply and support complexes in Virginia, Maryland and the Carolinas, a reasonable assumption would be that a heavy volume of logistics-related traffic is in the total shown for that entity.

By plotting all the originators in the sample on a cumulative basis, one can obtain the Lorenz curve of Figure 5, which graphically portrays the concentration of activity in a few user communities. Were all originators exactly the same size in terms of volume, the plot of cumulative percent of OSRI's (horizontal axis) against cumulative percent of sample traffic would describe a straight line diagonal from lower left to upper right in Figure 5. The bending of the curve away from this diagonal is a graphic measure of the degree of concentration of activity. Less than 10 percent of the largest volume users, for instance, account for nearly 80 percent of the sample traffic. This is of significance in terms of the problem of predicting response to changing the cost allocation basis. The extensive aspect of predicting response can be largely solved if the behavior of only a small number of users can be predicted.

Table 6. TOP TEN USERS OF AUTODIN

	7-DIGIT OSRI	DESCRIPTION	PAYING AGENCY	VOLUME LINE-BLOCKS (000'S)	PERCENT OF SAMPLE TOTAL
1.	RUVARIA	Air Force Logistics Command	Air Force	1,387	1.72
2.	QUEKJCS	Joint Chiefs of Staff	Army	1,187	1.43
3.	RULYSGG	5th Naval District	Navy	1,129	1.40
4.	RUEOUAA	Defense Logistics Service Center	DLA	1,112	1.38
5.	RUWTZZA	Defense Automatic Addressing System, California	DLA	1,084	1.34
6.	RUEBUAA	Defense Logistics Service Center	DLA	1,068	1.32
7.	RUCIZZB	Defense Automatic Addressing System, Ohio	DLA	1,019	1.26
8.	RUHGSGG	Pacific Area AUTODIN	Navy	1,007	1.24
9.	RUCIZZC	Defense Automatic Addressing System, Ohio	DLA	992	1.23
10.	RUFRSGG	European Area AUTODIN Access Lines	NAVY	991	1.23

Fraction of Originating Station = approximately 0.1%.

Fraction of Sample Traffic = 13.55.

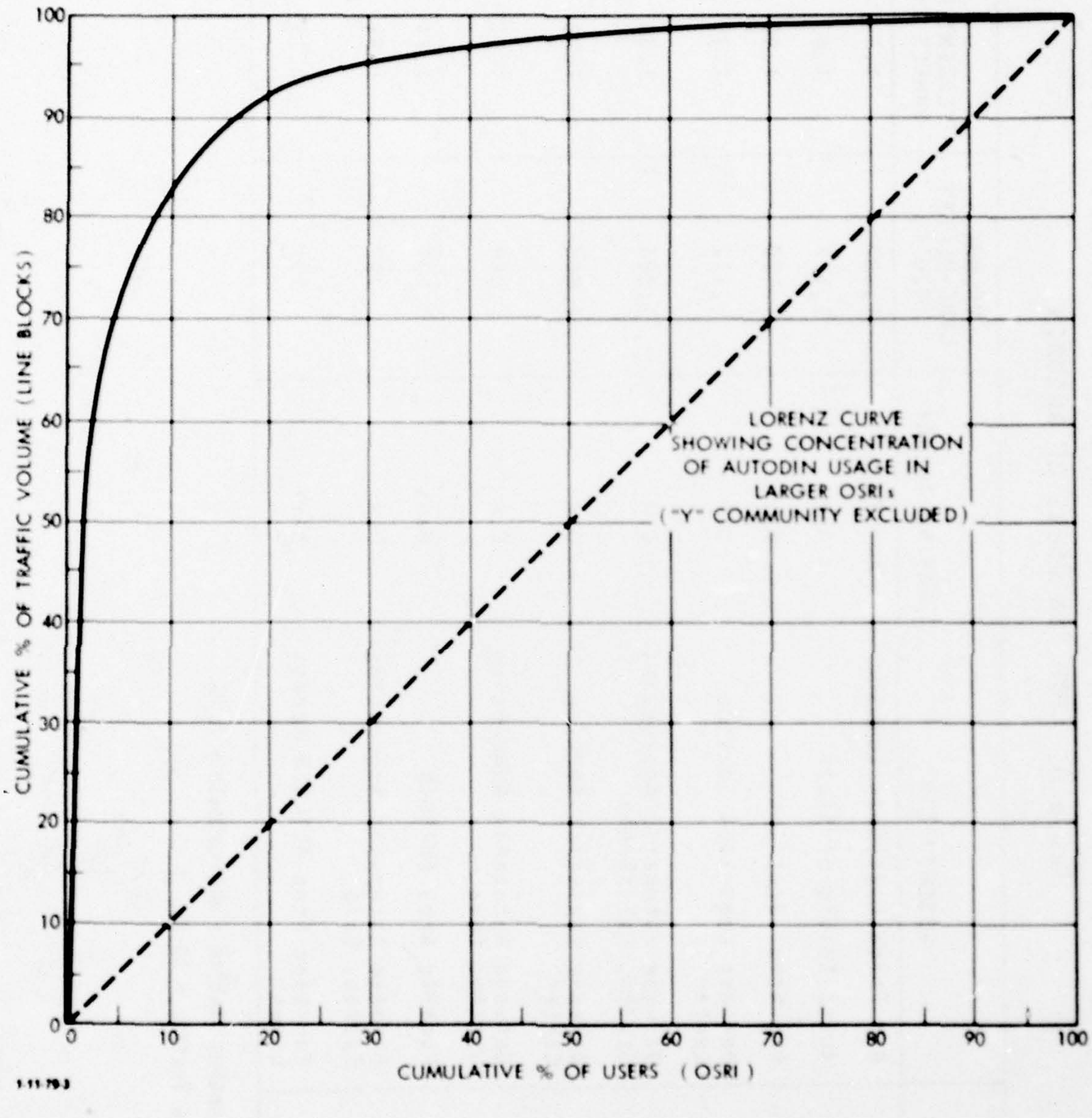

Figure 5. AUTODIN USAGE CONCEN:RATION

Since the sample was for a continuous seven day period and was provided in daily subsamples, it was possible to examine the time patterns of transmission. Plotting the data for total traffic by day-of-the-week yields the results shown as a solid line in Figure 6. The weekly traffic peak on Tuesday seems like a reasonable result. Certainly, one would wish to check against other samples to verify the pattern.[1]

Any number of traffic analyses become possible using the header extract data, but a principal study concern was to examine the use of similar information for usage billing by DCA. In the following section an illustration of the way annual costs would be allocated if the seven day sample were representative of annual use is explored.

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[1]The result of plotting FLASH and "higher" (meaning intelligence) precedence traffic, shown in Figure 6 as a dotted line, serves as a caution against generalizing from samples. The apparent Wednesday peak was puzzling until the authors checked the New York Times index for this period to discover that President Carter was en route from Japan to India and Europe on this particular Wednesday--and the bulge in traffic turned out to be concentrated to and from Pacific area switching centers.

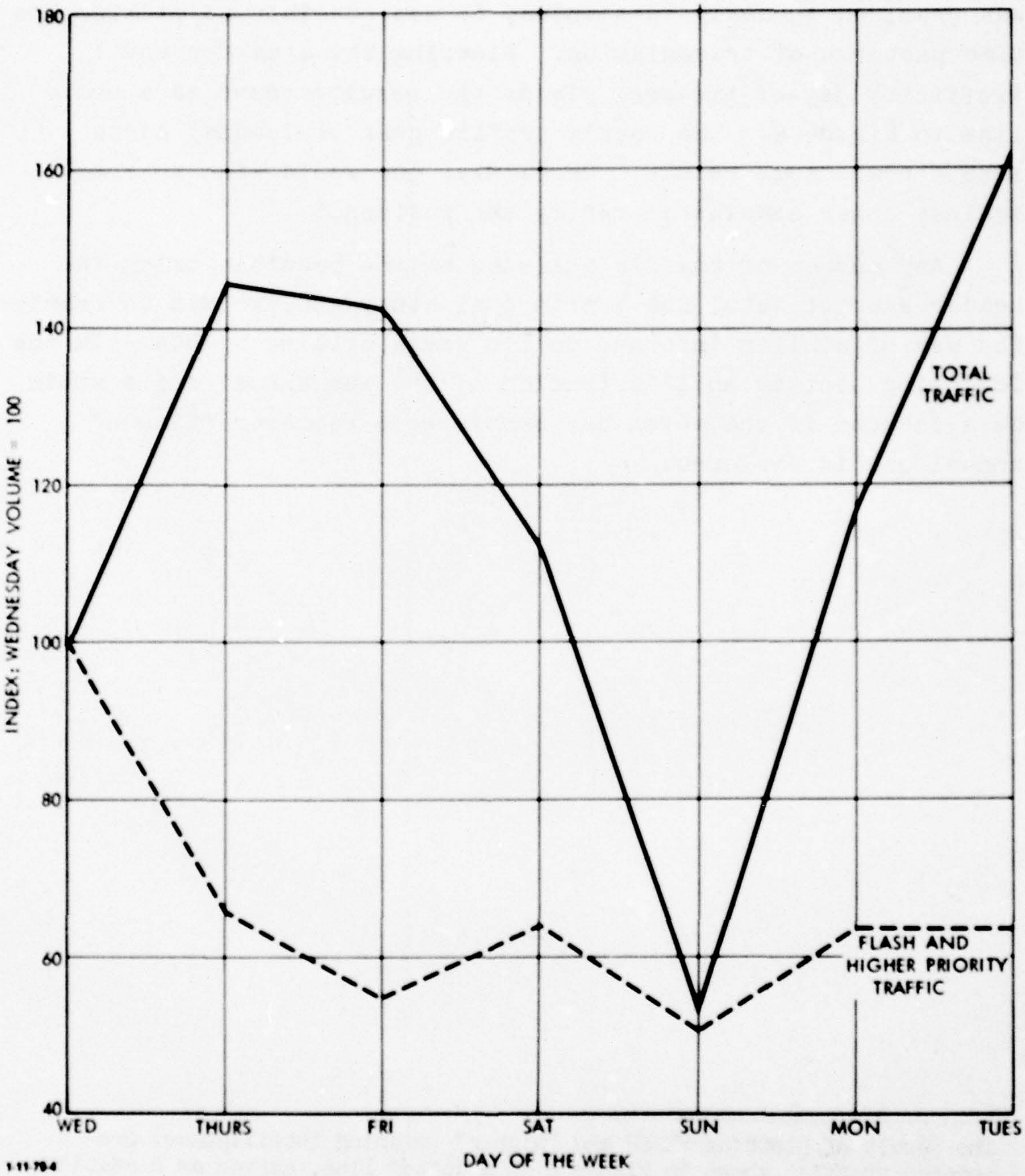

Figure 6. WEEKLY PATTERN OF MESSAGE TRAFFIC

V. DEVELOPING THE COST ALLOCATION MODEL

The analysis of the usage data provides a picture of the AUTODIN system dynamics. Essentially, the cost allocation model merely adds the step of applying a set of rates to the usage and access categories. The flow of information and the order of processing steps of interest to DCA technical personnel (who must implement a billing program) is best appreciated from Appendices A-D. In this section we will merely sketch the steps and give some of the numbers used in the cost-allocation computer program, partly to provide a background for the discussion of forecasting to follow.

As mentioned above, each AUTODIN transmission (message) is sent with a "header" of digital data to provide the automatic switching system with the information that its computer programs require for expeditious routing and handling of transmissions. This header is stored on the tape, along with the message at the switch, for a period of time after transmission for various reasons, including the possibility of transmission garbles that will cause the recipient to request a retransmission. As a special one-time effort, DCA extracted the message headers for a seven day period for all switches in the system. This "Header Extract" tape was made available to the study authors as a data source for building and testing the cost-allocation model. Basically, the steps in processing the data for study purposes prefigure the processing which DCA will have to perform repetitively to implement a billing program that would allocate charges in the same way.

The kinds of data contained on the Header Extract tape can be seen in Figure 7, which lists the data elements in the order in which they appear in each entry. For every message, that is to say for every identifiable transmission (complete with start-of-message and end-of-message signals), there is an entry in the Header Extract file with all these characteristics.

In order to accumulate these records into a measure of usage volume appropriate to the cost-allocation rationale of the previous study, we need an identification of "local," "area" and "inter-area" transmissions. By using the schematic representation of the AUTODIN switches and trunks in Figure 1, we can describe these categories in simple terms. If some Army office at, say, Fort Benning, Georgia, wished to send a message to a Coast Guard facility in North Carolina, the message might travel over an Army-controlled access line to the Albany switch, there to be routed over a Navy-controlled access line serving the Coast Guard facility via an extension from a Navy terminal. Such a message would be "local," since it would involve only the one switching center and no trunk lines. Should the same Fort Benning office send a message to the Presidio in San Francisco, the message could go by a number of routes, but would have to finally arrive at the McClellan Air Force Base switch to be sent out via a local access line to the Presidio. In the process it would utilize at least two (actually a minimum of three in this case) switches and some portion of the connecting trunks within the CONUS area. This is an "area" message. An "inter-area" message would be one utilizing the overseas connecting trunks either from McClellan and Norton (to or from the Pacific area) or the Andrews and Fort Detrick connections to Europe.

The local, area and inter-area classification depends upon the location of the switches which serve the originator and recipient of any message. One can easily set down, in matrix

Character	Contents
1	Precedence
2-3	Language Media Format
4	Security
5	Orginating ASC
6	Next ASC
7	Input Channel Type
8-14	Originating Station Routing Indicator
15-18	Originating Station Serial Number
19-21	Line Block Count
22-28	Time of File
29-35	System-in-Time
36-42	Start-of-Message-in
43-47	End-of-Message-Out
48-54	Start-of-Message-Out
55-59	End-of-Message-Out
60-62	Routing Indicator Count
63-69	Destination Routing Indicator
70-72	Input Channel Number
73-75	Destination Number
76	Reporting ASC
77-79	Output Channel Number
80	Output Channel Type
81-84	Content Indicator Code
85	Query Response
86	Sequential Delivery
87-89	TCC TRC ALPS Code
90	Special Category Code

Figure 7. HEADER EXTRACT
(90 Characters)

form, all the possibilities: Figure 8 shows this for AUTODIN as currently constituted.[1] Notice that in Figure 7, the Header Extract gives us these two essential bits of data--Originating ASC (Automatic Switching Center) and Destination ASC.

We also have the precedence, permitting separate cumulations of high precedence messages (precedence was considered as a cost-allocation criterion in the 1977 study). The length of the message in line blocks also is given in the header.

The OSRI's, which identify the sender and receiver, are not accounting designations for budget purposes, so that identifying usage in the Header Extract data with a budget cost center (PDC) involves additional processing steps. Each switching center maintains a file called the AUTODIN MANAGEMENT Index (AMIE), which lists each OSRI and the access line which services it. The PDC, which is charged with paying for AUTODIN access via that line, is determined from files maintained by DECCO. The study used a recent copy of this file and some other DCA sources to update it for changes. The file, which is critical to routing messages over the network, is updated weekly. Though seven days in length, the sample period fell in two separate weeks. Of course, when DCA implements the usage accounting program, it will have the updated file for each week as a part of the procedure.

The flow of information processing necessary to allocate costs, utilizing the Header Extract file, is described in Appendices A-D. However, the prior step of setting the rates which determine the cost allocations must be done outside the cost allocation (or for DCA, "billing") program. For this step one needs estimates of:

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[1]The Okinawa switch has been inactivated during the 1978 sample period--so only 16 switches are shown. The four character codes (RUEB, RUCL, etc.) are used in all routing indicators to specify the "home" switch of an addressee.

SWITCH	To / From	Andrews A	Albany B	Clark AB C	Detrick D	Croughton E	Guam F	Gentile G	Hancock H	Drake J	McClellan M	Norton N	Pirmasen P	Coltano Q	Taegu R	Tinker T	Honolulu W
RUEB - Andrews, MD	A	L	A	I	A	I	I	A	A	I	A	A	I	I	I	A	I
RUCL - Albany, GA	B	A	L	I	A	I	I	A	A	I	A	A	I	I	I	A	I
RUMM - Clark AB, PI	C	I	I	L	I	I	A	I	I	A	I	I	I	I	A	I	A
RUEO - Detrick, MD	D	A	A	I	L	I	I	A	A	I	A	A	I	I	I	A	I
RUDO - Croughton, Eng	E	I	I	I	I	L	I	I	I	I	I	I	A	A	I	I	I
RUHJ - Guam	F	I	I	A	I	I	L	I	I	A	I	I	I	I	A	I	A
RUCI - Gentile, OH	G	A	A	I	A	I	I	L	A	I	A	A	I	I	I	A	I
RUED - Hancock, NY	H	A	A	I	A	I	I	A	L	I	A	A	I	I	I	A	I
RUAD - Drake, Japan	J	I	I	A	I	I	A	I	I	L	I	I	I	I	A	I	A
RUWM - McClellan AFB, CA	M	A	A	I	A	I	I	A	A	I	L	A	I	I	I	A	I
RUWJ - Norton AFB, CA	N	A	A	I	A	I	I	A	A	I	A	L	I	I	I	A	I
RUFT - Pirmasen, FRG	P	I	I	I	I	A	I	I	I	I	I	I	L	A	I	I	I
RUFL - Coltano, Italy	Q	I	I	I	I	A	I	I	I	I	I	I	A	L	I	I	I
RUAK - Taegu, ROK	R	I	I	A	I	I	A	I	I	A	I	I	I	I	L	I	A
RUWT - Tinker AFB, OK	T	A	A	I	A	I	I	A	A	I	A	A	I	I	I	L	I
RUHH - Honolulu, HI	W	I	I	A	I	I	A	I	I	A	I	I	I	I	A	I	L

L = Local

A = Area

I = Inter-Area

Figure 8. DISTANCE CHARGE: SWITCH-TO-SWITCH MATRIX

- Switch and overhead costs
- Trunk cost estimates by area
- Number of trunks by area
- The ADU (Accumulation and Distribution Unit)[1] capacity of the switches in line blocks
- The estimated number of access lines, by speed category
- The fraction of total switch cost accounted for by the ADU function.

Since the current DCA weights for various speed lines are in proportion to their ADU memory use, and since each trunk connection is assigned the same amount of ADU memory space as a high-speed access line, the access charge for any type line can be computed as:

$$c_i = w_i \left(\frac{\alpha (C_s)}{\sum (w_i \ a_j)} \right)$$

Where:

c_i = access charge for each class of line (high, medium, low)

w_i = weight assigned to speed class (14:9:3)

a_j = number of connected lines (including trunks) in each class

C_s = cost of the switches

α = fraction of switch cost assignable to ADU function.

[1]The ADU or Accumulation and Distribution Unit is the element in the leased switch which coordinates message input and output. It utilizes a computer memory unit of fixed capacity and is the first constraint on capacity of AUTODIN. The model of the previous study argued for an access charge based upon the ratio of ADU capacity required for access lines to total ADU capacity applied to ADU cost. The remainder of ADU cost was to be allocated on the basis of trunk line utilization of ADU capacity. The cost of the remainder of the switching system was to be allocated over all units of usage regardless of distance, with an added amount for the area units of usage to cover trunk costs in the various areas and an additional amount to inter-area usage units to cover overseas (inter-area) trunk costs. For the reader without access to IDA Study S-487, an excerpt from that document describing the rate-determining model is included in Appendix E.

In IDA S-487 the parameter "α" was based upon estimates taken from ICC tariffs, at something between .20 and .25. However, it can serve as a policy variable. In those terms, current (1978) DCA policy is equivalent to assigning "α" a value of 1.0--all costs to be recovered from an access charge. The argument for keeping "α" fairly low is that additional access lines do not add to the common user cost directly or when the result is an increase in system throughput. Therefore, legitimate AUTODIN users should be encouraged to utilize the system's idle capacity by means of additional access lines, if necessary. Whether their missions are thus more effectively carried out or their communications costs for a given mission reduced, the result is an improvement--from the AUTODIN backbone manager's viewpoint. One is bound to note, however, that the cost of the access line itself is not included in this limited AUTODIN cost concept. It is conceivable that including such a cost within the AUTODIN calculation would tend to make the number of instances of potential net gain from increased access somewhat fewer than the "backbone cost only" view.[1]

Estimating the number of access lines by speed class is not a major problem for DCA. Its using agencies are accustomed to making such estimates of their own use as a basis for budgeting. In this study we have found that using the FY 1978 estimate for total lines from DCA planning documents gives a result close to what is obtained by counting the number of separately identified access lines in the seven day sample.[2]

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[1]It is recommended that in subsequent economic analyses some larger "systems" concepts and optimization questions be addressed.

[2]The Header Extract and AMIE file identify access lines via their "CCSD" numbers. These Command Communications Service Designators are 8 digit alpha numeric identifiers coded to indicate the operational control agency, the country of origin on the line and, by number, a serial number for the line. Because the data used were "blinded" to certain types of traffic and OSRI and access line information, the DCA planning document number for total access lines in FY 1977 was used for calculation.

The costs of the system (Table 7) are determined primarily by annual lease contracts and typically are based upon FCC tariffs which are changed only through judicial and administrative procedures. In our illustrations, as was indicated above, we have simplified the cost categories to only two, namely "trunk" costs and "switch" costs. This involved arbitrary assumptions about the distribution of overseas trunkline costs as shown in Table 7 (which shows the combined Atlantic-spanning and intra-Europe trunk costs) between "area" amd "inter-area" categories. The figures used are shown in the illustrative examples below.[1]

Since the backbone costs are fixed by annual contract, the calculation of per unit volume rates to recover these costs requires an estimate of annual volume by distance category. This is a more difficult estimation problem than the access line case, since neither DCA nor the users had to estimate volume for budget planning purposes. The traffic engineers charged with providing network capacity have had to consider anticipated traffic volumes *in specific cases of changed missions* in order to meet grade of service requirements. The volume of switch-to-switch traffic is sampled for this and other operations purposes on a two days per month basis. Checks against these samples show that the annual volume estimate derived by simply multiplying the study's seven day sample by 52 was within five percent of the value derived by multiplying the other one day samples by 300 (an approximation of the military business year).

With a finer analysis of usage that will be possible if the data collection program recommended in the study is implemented, *overall* volume estimation, as well as the distribution of total traffic distance categories, should not be a problem.

[1] DCA would, of course, use the actual direct lease costs for the CONUS to Europe and CONUS to Pacific (Hawaii, Guam and Japan) trunk lines from their exact records.

TABLE 7. SIMPLIFIED AUTODIN BUDGET FOR COSTING ILLUSTRATIONS (BASED ON DCA FY 1978 SUBMISSION)

Switching Centers:		
Leased Switches		$32,100,000
Amortization		700,000
O&M of Switching Centers		13,900,000
Other Switch-Related		200,000
SUB-TOTAL		$47,000,000
Trucks		
	Number	
CONUS (Leased)	19	$ 380,000
Europe	14	880,000
Pacific	12	1,090,000
SUB-TOTAL		$ 2,350,000
Other General Expenses		1,650,000
TOTAL		$51,000,000

Estimating usage volume at the lower user levels is another problem to be discussed later.

The various distance rates can be computed, once the volume estimates are made, as follows (in $/line block):

$$\text{Local rate} = \frac{\text{Switch Costs } (1 - a)}{\text{Total Volume}}$$

$$\text{Area rate} = \frac{\text{Local rate} + (T_{AT} \times 14 \times V_W) + T_{AC}}{\text{Area Volume}}$$

$$\text{Inter-area rate} = \frac{\text{Area rate} + (I_{AT} \times 14 \times V_W) + I_{AC}}{\text{Inter-area Volume}}$$

Where: T_{AT} = Area trunk terminations = (no. of trunks x 2)

V_W = Connectivity weighted unit value in dollars

T_{AC} = Area trunk lease costs

I_{AT} = Inter-area trunk terminations

I_{AC} = Inter-area trunk lease costs and message volumes are all measured in line blocks

Once the access and volume rates have been calculated, they become inputs to the cost-allocation program. After identifying the speed class and PDC of the access time, this program multiplies by the appropriate rate for connectivity. Then the line-block totals for each sending OSRI, by distance class as determined by the destination/origin switch matrix, are produced by summing the Header Extract data. These are then multiplied by the appropriate line-block rates for each distance class. The program then lists under each PDC a subaccount by access line showing the access charge, each OSRI's usage charges over that access line, and the subtotals of access, usage, and access plus usage. These subaccounts are summed to produce (to conform to present billing practices) usage and access subtotals and a grand total for each PDC.[1]

In summary, the cost-allocation model developed as a prototype for DCA's billing procedure can be described conceptually[2] as consisting of three steps. They are:

(1) Classifying and accumulating the usage information into distance and precedence category totals for each user (OSRI)

(2) Computing the usage charges for each user based upon rate inputs

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[1]The actual inputs were weekly data for volume, monthly charges for access. The first was multiplied by 52 to annualize usage costs. The access line charges were multiplied by 12 to complete the annualization.

[2]The technical specifications in Appendix A are the appropriate source for a functional description of how these conceptual steps are accomplished.

(3) Combining user identified usage (OSRI) charges and cost center (PDC) access line charges into a statement of backbone cost liability.

A prior step involves computing the rate inputs based upon the process described in the preceding section. Annual costs, estimates of annual volume of usage by category and total annual months of access line and trunk connection, are combined in the IDA S-487 costing formulae, along with the policy parameter for the ADU memory cost. Tables 8 and 9 show the computations as used for illustrative purposes in the study.

A facimile of a portion of the computer printout which the cost-allocation model produces is shown in Figure 9, with explanatory footnotes. The numbers in that printout are on an annual basis, as are the numbers in the analysis in succeeding paragraphs. In practice, however, such allocations could be made on as short a period as desired.

The cost allocation by major agency resulting from the illustrative parameters is shown in Table 10, below. Several of the more obvious aspects of this allocation are worthy of comment. The fact that the three uniformed services and the Defense Logistics Agency would account for more than 80 percent of the total charge tells us that usage charges are not likely to shift the burden away from the major agencies. We note also that the only other major user is the "classified community," which refers to the intelligence-related communications for which our data sample contained no originator identification. We were informed that a substantial fraction of this traffic could well have originated with agencies and offices already identified in the sample types with associated nonintelligence traffic volumes. Thus, we have assumed that in the actual billing process of DCA, where the originating agency will be known to the accounting authorities at DECCO, the allocation of this classified traffic will not alter the basic shares as indicated in our analysis.

Table 8 SAMPLE AUTODIN BACKBONE SYSTEM PARAMETERS[a]

CONNECTIVITY MEASURES (ANNUAL BASIS)		
ACCESS LINE CONNECTIONS (ALL SPEEDS)	=	84,000 weighted units (N)
AREA INTERSWITCH TRUNKS = 37	=	12,432 weighted units
INTER-AREA INTERSWITCH TRUNKS = 14	=	4,704 weighted units
TOTAL	=	101,136

COSTS (ANNUAL BASIS)		
AREA TRUNKS	$ 600,000	(T_c)
INTER-AREA TRUNKS	1,750,000	(T_{os})
SWITCH AND OTHER SYSTEM COSTS	48,650,000	(S)
TOTAL =	$51,000,000	

USAGE VOLUME: (Annual Basis): LINE BLOCKS[b]			
LOCAL	=	1,417,213,600	(X)
AREA	=	2,206,716,200	(Y)
INTER-AREA	=	905,575,700	(Z)
TOTAL	=	4,259,505,500	

[a]Symbols in parentheses refer to terms in rate equations of S-487.
[b]DCA 7-day sample values x 52.

Another item to note is that the use of the parameter 27.5 percent for the portion of switch costs to connectivity results in an allocation of about 22 percent of total cost to connectivity or 78 percent to usage. However, a glance at the numbers shows that there are wide variations across agencies in the division of costs between the connectivity charge and usage rates. Under the proposed rates, for instance,

Table 9. AUTODIN SYSTEM: SAMPLE RATE CALCULATIONS

POLICY PARAMETER:

$\alpha = .275$

COMPUTATION OF "a" and "b"

MEMORY USED IS PROPORTIONAL TO WEIGHTED UNITS

$$\text{THUS} \quad a = \frac{12,432}{101,136} = .123$$

$$b = \frac{4,204}{101,136} = .047$$

COMPUTATION OF D and d

$$D = (1-a-b)R \quad \text{where } R = \alpha S$$

$$D = (1 - .123 - .047)\ (48,650,000 \times .275)$$

$$D = \$11,140,000$$

$$d = \frac{D}{N} = \frac{11,140,000}{84,000} = \$133 \text{ per weighted unit} = \$130 \text{ (rounded)}$$

COMPUTATION OF C_1, C_2, C_3

$$C_1 = \frac{S-R}{x+y+z} = \frac{35,230,000}{5,259,505,500} = \$.00827 = \$.008$$

$$C_2 = \frac{S-R}{x+y+z} + \frac{aR+T_c}{y+z} = .00827 + \frac{2,250,000}{3,112,291,900} = .00897 = \$.009$$

$$C_3 = \frac{S-R}{x+y+z} + \frac{aR+T_c}{y+z} + \frac{bR+T_{os}}{z} = .00897 + \frac{2,380,000}{905,575,700} = .01157 = \$.012$$

the Air Force and Army would be paying about 71 percent on a usage basis; the Navy would pay almost 77 percent; DCA would pay about 76 percent. But the Defense Logistics Agency would pay about 92 percent for usage and FAA only 13 percent!

What these percentages tell us is how intensively each agency is using its access lines, at least in a relative sense. This is not, of course, a measure of efficiency. It would be so, however, if each agency was identical (or nearly so) with

POC		CSA		CCSD	ITEM	LOCAL	AREA	INTER-AREA	OSRI TOTAL	SUBTOTAL	TOTAL
					TOTAL	11922.37	9157.36	156.62	20036.35	20036.35	29916.38
AAGAD	TOTAL[1]					273076.77	700030.34	236712.26	1200827.36[2]	171600.00[3]	1470127.36[4]
AAGCD	WU	T	05120[5]	JUAETV0D[6]	CONNECTIVITY					4600.00[8]	
					[illegible][7]	997.44	1376.52	1397.16	3329.00		
					TOTAL	997.44	1376.52	1397.16	3329.00	3329.00[9]	8009.00[10]
AAGCD	TOTAL					997.44	1376.52	1397.16	3329.00	4690.00	8009.00
AAGED	WU	D	11406	JUEETW02	CONNECTIVITY					14040.00	
					[illegible]	6217.94	9031.46	1395.26	16644.26		
					TOTAL	6217.94	9031.46	1395.26	16644.26	16644.26	30084.26
AAGEN	WU	D	00492	JUEE7210	CONNECTIVITY					4600.00	
					[illegible]	366.96	256.46	197.01	820.77		
					TOTAL	366.96	256.46	197.01	820.77	820.77	9500.77
AAGFD	WU	D	00017	JUEE7722	CONNECTIVITY					14040.00	
					[illegible][11]	1297.97	6010.01	2607.70	9003.20		
					[illegible]	570.16	407.10	95.54	1001.03		
					[illegible]	473.07	533.52	29.95	906.54		
					[illegible]	452.10	11.23	0.00	463.42		
					[illegible]	349.40	9.74	0.00	359.42		
					[illegible]	315.74	30.38	0.00	394.12		
					[illegible]	265.02	34.50	0.00	302.33		
					[illegible]	14.56	157.72	0.00	172.28		
					[illegible]	9.15	87.05	0.00	96.20		
					TOTAL	3632.93	7293.31	2693.10	13619.42	13619.42	27659.42

[1] This line gives the total (from previous pages in this instance) for the POC. AAGA includes the Air Training Command's terminals and tributary message center.

[2] This is the usage subtotal of the three subtotals of Local, Area and Inter-area charges.

[3] This is the subtotal of connectivity charges for AAGA.

[4] This is the total charge (2 + 3).

[5] WU T 05120 identifies the operational controller and the authorization number (CSA) for an access line. This is a Western Union leased line.

[6] This number further identifies the access line for the AMIE file which relates it to a speed code, a POC and a geographic point-to-point descriptor.

[7] This is an OSRI. The first four characters identify the home switch, (AMEB - Andrews AFB, Md.), the second three characters uniquely identify the activity.

[8] This is the connectivity charge for access line JUAETV 0D. In this case we know it is a low-speed line.

[9] This is a subtotal of usage charges for this access line.

[10] This is total charges for the access line. Since this POC (AAGC) has only one line and one OSRI, the total line is repetitious.

[11] This access line has nine OSRI's using it. Note the variation among them, the largest having charges almost 100 times those of the smallest.

Figure 9. COST ALLOCATION MODEL: SAMPLE OUTPUT

Table 10. ALLOCATION OF AUTODIN BACKBONE COSTS[a]

Agency	Costs ($ 000's)		
	Connectivity	Usage	Total
Air Force	$4,049	$ 9,922	$13,970
Army	3,246	7,847	11,094
Navy	2,329	7,738	10,068
Defense Logistics Agency	621	7,011	7,632
Defense Communications Agency	220	680	900
Federal Aviation Agency	178	26	204
Defense Mapping Agency	33	57	90
State Department	--[b]	56	56
Armed Services Info. Office	5	133	138
General Services Administration	5	181	186
Classified Community	--[b]	4,672	4,672
Others	414	576	1,090
TOTAL	$11,110	$38,900	$51,000

[a]Based on: Connectivity weighted unit = $130.000
Usage rate per line block
local = $ 0.008
area = $ 0.009
inter-area = $ 0.012

[b]Distributed over and accounted for in other agencies

respect to the nature and geographic distribution of its communications demands. But we know, for instance, that DLA has relatively few centralized activities in a few locations processing large data volumes on a routine basis and using only high speed lines. The FAA, on the other hand, has a network of facilities distributed fairly uniformly over the North American continent to provide coverage of the air space for contingency

purposes. It may be that within the uniformed services, there are groups of users with contingency-related access lines similar to FAA. However, because defense activities tend to be geographically clustered, other users in the vicinity with routine peace-time communications needs can make use of these access lines, so that usage/access ratios are similar across the major user categories.

VI. PREDICTING RESPONSE TO USAGE CHARGES: DEMAND THEORY[1]

Our illustration has shown what the distribution of costs among users would have been for the rates as shown and assuming the one week sample as representative of the annual usage volume and distribution. The computer program used for processing the data to get these results (as we were able to demonstrate for officials of the responsible activities at the Defense Commercial Communications Office) could be used to process actual usage data on a monthly basis and bill each agency for its AUTODIN services. However, the current budget procedures and policies require that each budget accounting entity include in its appropriations request, which precedes the fiscal year by 18 months, an amount to cover its payments to DCA for AUTODIN (as well as AUTOVON) services. In order to assure that payments from these customers will reimburse the Communications Services Industrial Fund, DCA must set rates for services based on customer usage estimates. Under the connectivity-only rate system currently used, the estimation problem has apparently not been too difficult; at least since the stabilization of the armed forces size and location since the end of the Vietnam emergency. In proposing to change the rate basis fairly radically, the usage-sensitive rate policy requires a new emphasis on estimating future demand.

[1]The following analysis was developed by Bridger M. Mitchell in "Optimal Pricing of Local Telephone Service," published in *The American Economic Review*, September, 1978, Vol. 68, No. 4, pp 517-537.

AUTODIN utilization includes both the number of direct user connections and the amount of usage (messages or lines of information transmitted). Connection decisions are approved by communications managers acting on requests from actual users, providing the requests meet operational guidelines of the Joint Chiefs, who are the authorizing authority for access. While day-to-day usage decisions are made by operatives, they are constrained by the design of the user system and by usage procedures. Thus administrators influence usage decisions as well.

There are a number of alternative ways in which user communication needs can be met. AUTODIN can be accessed indirectly by feeding messages through connected switchboards of other users. Dedicated lines can be leased from commercial sources. Effort can be directed toward reducing the number of error-caused repeat messages.

To the extent they have choices, administrators may seek to minimize the budget cost of providing a given level of communications services. For example, administrators may be able to transfer funds saved in the communications budget to the budgets for other functions. Alternatively, they may seek to provide the maximum level or quality of communications services possible, given their communications budgets. In any event, the users can be expected to respond to changes in AUTODIN prices by changing the nature of their utilization of AUTODIN.

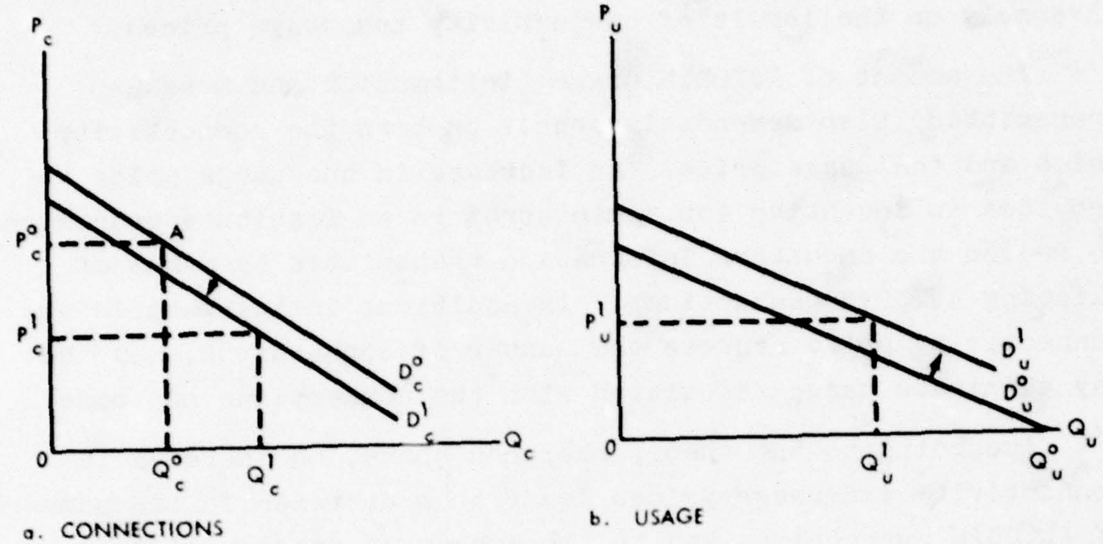
In making their connection decisions, administrators consider the total budget cost of performing a particular communications service, under both AUTODIN and other methods. If either the connectivity price or the usage price is increased, the budget cost for the AUTODIN alternative increases. For at least some communications services, such an increase is sufficient to cause administrators to decide against connecting

to AUTODIN. Thus the demand for AUTODIN connections depends inversely on the levels of connectivity and usage prices.

The amount of AUTODIN usage (information and messages transmitted) also depends inversely on both the connectivity price and the usage price. An increase in the usage price provides an incentive for administrators to institute procedures to reduce the amount of information transmitted by means of existing AUTODIN connections. In addition, an increase in the connectivity price reduces the number of connections, and thus may eliminate usage associated with the connections not made.

According to the theory sketched above, an increase in connectivity and usage prices leads to a decrease in the number of AUTODIN connections and in the amount of usage. Also, price decreases lead to increases in the number of connections and in the amount of usage. But the proposal for usage-sensitive pricing calls for a decrease in the connectivity price, and for an increase (from zero) in the usage price. Because changing the two prices in opposite directions leads to conflicting administrative incentives, the net effect on AUTODIN utilization depends on the characteristics of the demand relationships, and on the amounts of the price changes. The process can be illustrated by means of the graphs in Figure 10a and Figure 10b.

These graphs show the relationships among connectivity and usage demands and prices. To read the graphs, note that the vertical axes measure price levels, and the horizontal axes measure quantities demanded. Values equal zero at the intersection of two axes, and increase as you read away from the intersection. The straight lines which slope downward (from left to right) are demand curves. Each point on a demand curve shows the quantity which would be demanded at a particular price. The quantity corresponding to a particular point on a demand curve is the value assigned to the point directly below it on the horizontal axis. Similarly, the price corresponding to a



Figures 10a and 10b. NOTIONAL DEMAND FOR COMMUNICATION SERVICES

particular point on a demand curve is the value assigned to the point directly to the left of it on the vertical axis. For example, in Figure 10a, the point labelled A on the demand curve labelled D_c^o represents the quantity Q_c^o and the price P_c^o.

The demand curve labelled D_c^o in Figure 10_a depicts the relationship between the number of connections (Q_c) demanded and the connectivity price (P_c), assuming that the usage price (P_u) remains constant at the level 0. The demand curve (D_c^o) slopes downward (from left to right), showing that the demand for connections increases as the connectivity price decreases. Similarly, the demand curve (D_u^o) in Figure 10b depicts the inverse relationship between the demand (Q_u) for usage and the usage price (P_u), given that the connectivity price remains constant at the level P_c^o. In the base situation, with connectivity and usage prices equal to P_c^o and 0, (respectively), the corresponsing connectivity and usage demands equal Q_c^o and Q_u^o.

Under usage-sensitive pricing, the usage price is increased to some positive level, say P_u^1. The revenue thereby generated permits a reduction of the connectivity price, say to P_c^1.[1] Since connectivity demand depends inversely on usage price, the increase in usage price means that fewer connections are demanded at each connectivity price; thus, the connectivity demand curve in Figure 10a shifts inward to D_c^1. Similarly, the decrease in connectivity price to P_c^1 causes the usage demand curve in Figure 10b to shift outward, to D_u^1. Connectivity and usage demands under usage-sensitive pricing are those demands (Q_c^1, Q_u^1) associated with the usage-sensitive prices (P_c^1, P_u^1) on the new demand curves (D_c^1, D_u^1).

Figures 10a and 10b are drawn so that usage-sensitive pricing results in an increase in the number of connections (from Q_c^o to Q_c^1) and in a decrease in the amount of usage (from Q_u^o to Q_1^o). The results which would actually occur depend on the levels at which usage-sensitive prices would be set, and on the characteristics of the connectivity and usage demand relationships.

The degree of response of connection demand to a change in connection prices is measured by the *elasticity of demand*[2] for connections.

This is, in terms of the graphs, defined as

$$\eta_c = - \frac{P_c}{Q_c} \cdot \frac{dQ_c}{dP_c}$$

---

[1] In theory, demand for connections could be so responsive to changes in the price of connections that reducing that price would result in an increase in connection revenue. However, the proposal for usage-sensitive pricing assumes that event to be unlikely.

[2] These are "point" elasticities, that is, instantaneous rates of change. "Arc" elasticities which are often not consistent with basic analytical techniques are used in later illustrative material. Arc elasticity would be $E_u = - \frac{P_u}{Q_u} \cdot \frac{\Delta Q_u}{\Delta P_u}$.

where η_c = elasticity of demand for connections

P_c = initial price of connection

Q_c = number of connections .

Similarly, the elasticity of demand for usage would be

$$\eta_u = - \frac{P_u}{Q_u} \cdot \frac{dQ_u}{dP_u} .$$

Mitchell[1] notes that very little empirical evidence for the values of these elasticities in residential and business telephone exists, but suggests a range of -0.1 to -0.4 for connections as a function of that rate charge and -0.1 to -0.7 for usage as a function of per call charges.

Such figures, of course, cannot be directly transferred to the analysis of AUTODIN demand, but they can provide some first approximations.

What one also needs to know (since as we note above, the connectivity rate and usage rate are varied together to cover the total cost) are the values of the cross-elasticities of demand. Cross-elasticity measures the demand response for one service to changes in the price of a complementary service. In our terms, the cross-elasticity of demand for usage, for instance, would be expressed as

$$\theta_{uc} = \frac{dQ_u/Q_u}{dP_c/P_c}$$

where

θ_{uc} = cross-elasticity of usage with respect to connection price.

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[1] *Op. cit.*, p. 526.

Similarly, the cross-elasticity of demand for connections would be

$$\theta_{cu} = \frac{dQ_c/Q_c}{dP_u/Pu}$$

where

θ_{cu} = cross-elasticity of connections with respect to usage price.

Just how the opposing effects will settle out can only be conjectured. One cannot assume without question that government agencies will behave as if they were individuals or business enterprises engaged in maximizing profit and thus posit similar responses. On the other hand, there is no well understood theoretical literature of bureaucracy which talks about quantitative responses to inter-bureau fund transfers such as are involved here. Some questions can be settled by making the rate changes and observing the response of the various agencies. However, the budget process requires that an estimate be made in advance. In the following section we discuss some of the ways in which the analysis of this study and its predecessor can be used to begin to narrow the band of uncertainty about system response to usage-sensitive pricing.

VII. PREDICTING RESPONSE TO USAGE-SENSITIVE PRICES: SPECULATIVE ILLUSTRATIONS

Absent any systematic data on price changes and user response or any theory of "bureaucratic" demand, we can rely on the basic principle that the response must lie, in every case, somewhere between what we would expect of a private business under similar circumstances and the completely perverse behavior of a bureau interested only in maximizing its budget and thus selecting the most costly of all alternatives offered. In the first case, we suggest how an estimate of user response based upon graphically estimated demand elasticities and utilizing a subsample of the data by access line[1] might be used to obtain a sort of "reasonable bound" on response in the aggregate. In the second, the cost-allocation model is run with various rate levels to examine the allocations that would result. This no-response example is still less than the absolute upper bound of the mythical budget maximizer.

For our example of estimating demand we will simply sketch some assumptions and use a graphic technique to hold our numerical speculation within bounds. The purpose is to illustrate economic reasoning. Given actual data containing responses to changes, one would proceed using regression analysis and other replicable methods. To simplify and shorten the discussion we have constructed the example using separate usage and connectivity elasticities. In practice the relevant measures include the cross-elasticities.

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[1]Because of the procedures used in processing, some data elements, correct in the aggregate, are incorrectly listed in some detailed printouts. Most are obvious and can be excluded from hand-drawn subsamples.

The graphic technique involves starting with the usage volumes and number of connections shown in the sample and in other DCA data sources. Then graphs similar to Figures 10a and 10b were constructed by assuming demand elasticities on the order of -0.1 to -0.4 for connections and for usage for high-speed users. The changes in connections and usage were then estimated separately (rather than attempting cross-elasticity analysis).

Let us assume that the elasticity of demand for connections is lowest for high-speed customers and highest for low-speed customers. For usage, we assume that high and low speed are more insensitive to usage charges than medium speed. The argument for this latter assumption is that high-speed users are principally data transmitters, with few alternatives other than AUTODIN and with quantities of data fixed by routine support requirements which do not vary. Low-speed users, at the opposite end, send very little except occasional test messages and these must travel AUTODIN--otherwise the relatively high-connection charge would not have been paid. The curve for the high-speed users becomes the guide for the other two which are sketched free hand. By using the same zero price point for each demand curve and changing the scales appropriately, numbers can be read off. The result, shown in Table 11, is consistent with the assumptions. Opposite results could be obtained almost as easily. Nonetheless, one is able to make a few points which are useful.

In Table 11, Part A, "Current Structure" is based on data. The FY 1978 revenue, with the existing connectivity-only rates, would be about $49.7 million (the loss-carryover is not included; thus the difference from $51 million used in other examples). If our elasticity estimates were correct, the structure of usage and connectivity rates derived in the previous sections would, as shown in Part B, produce revenues amounting to some

Table 11. FIRST ESTIMATE OF USER RESPONSE

A. Current Structure

Access Line Type	Number	Monthly Charge	Annual Revenue ($M)	Per Month Usage/Line (Line Blocks x 10^3)	Rate Per Line Block	Annual Revenue	Total
High Speed	130	$8400	13.1	2300	0	0	13.1
Medium	315	5400	20.4	220	0	0	20.4
Low	750	1800	16.2	40	0	0	16.2
TOTAL			49.7				49.7

B. Proposed Structure

Access Line Type	Number	Monthly Charge	Annual Revenue ($M)	Per Month Usage/Line (Line Blocks x 10^3)	Rate Per Line Block	Annual Revenue	Total
High Speed	150	$1820	3.3	2000	0.0094	33.8	37.1
Medium	410	1170	5.8	175	0.0094	8.1	13.9
Low	1000	390	4.7	35	0.0094	3.9	8.6
TOTAL			13.8			45.8	59.6

$59.6 million. Under our assumptions, the expansion of users resulting from the connectivity charge reduction would more than offset the decline in per customer usage (as opposed to a no-charge policy) resulting from the proposed charge for usage.

Note that, of the total, $13.8 million is assumed to be collected from connectivity and $45.8 million from usage. Were this a conclusion from data, one would want perhaps to consider reducing the average charge per line block, if the connectivity were unchanged. Given appropriate data, one would want to calculate cross-elasticities, which are appropriate to production response to changing both prices.

The other approach to ranging in on demand changes is to vary the parameters in the cost-allocation program, leaving message volumes and connections, that is to say the demand, unchanged. The result is the allocation if there were no response to changes in charges. The results for the major users are shown in Table 12 and in Figure 11.

The essence of the charge basis change implied by the earlier study recommendations can be seen in comparing the first two columns in Table 12 or noting the trends of the curves in Figure 11 from the left scale to the points specified by the dots. Changing the charge basis has the effect of selecting the pattern of cross-subsidy between Air Force and Army and the Defense Logistics Agency. Under the connectivity-only rate scheme the Air Force and Army can be thought of as subsidizing the Defense Logistics Agency's AUTODIN service. Under a purely usage-based rate system, the opposite would be true. While the three agencies mentioned are the only ones involving relatively large changes, the shift of charges in smaller agencies such as FAA and GSA, while relatively small, can bulk fairly large in their budgets. The $600,000 reduction that might occur in FAA's AUTODIN charge, for instance, would pay for a substantial number of GS-14 air controllers.

Table 12. VARIATIONS IN AUTODIN COST ALLOCATIONS
(All costs in thousands of dollars)

Agency	Connectivity Only (Present System)	[%]	27.5% Connectivity (Illustrative System)	[%]	Usage Charge Only	[%]
Air Force	$18,603	[36.5]	$13,970	[27.4]	$12,665	[24.8]
Army	14,914	[29.2]	11,094	[21.8]	10,016	[19.6]
Navy	10,701	[21.0]	10,068	[19.7]	9,987	[19.4]
DLA	2,853	[5.6]	7,632	[15.0]	8,949	[17.5]
DCA	1,011	[2.0]	900	[1.8]	947	[1.9]
FAA	818	[1.6]	204	[0.4]	34	[0.06]
GSA	23	[0.04]	186	[0.04]	231	[0.4]
Armed Services Info. Office	23	[0.04]	138	[0.3]	170	[0.3]
DMA	152	[0.3]	90	[0.2]	73	[0.1]
Classified Community[1]	NA		4,672	[9.2]	5,961	[11.7]
Others	1,902	[3.7]	2,046	[4.0]	2,079	[4.1]

[1]This is shown as a separate category for completeness only. Most of the messages are originated by and would be paid for from the budgets of organizations within the services and other agencies.

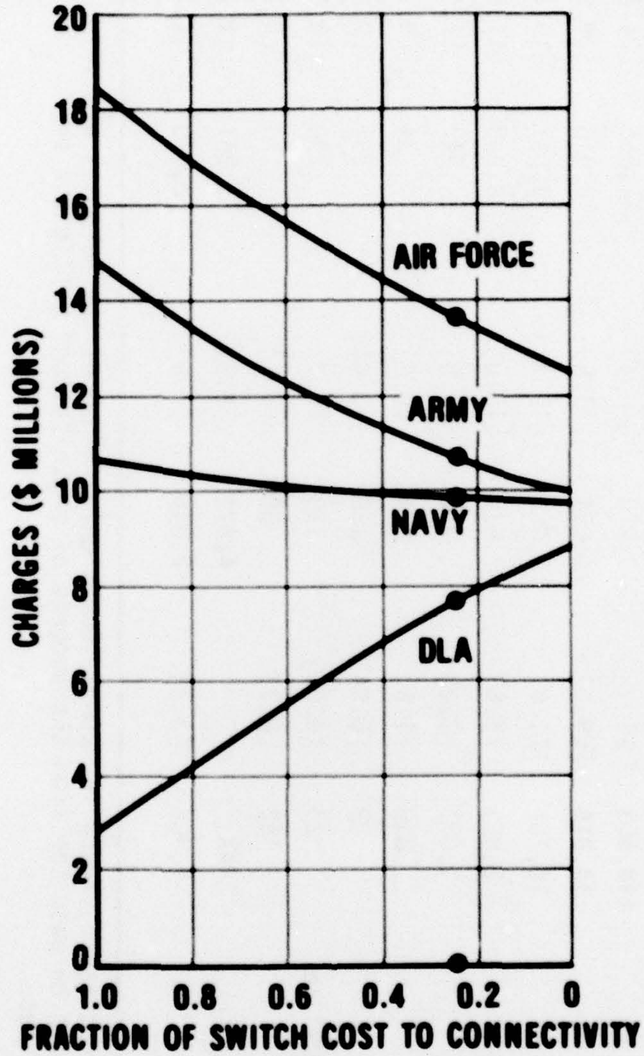

Figure 11. EFFECT OF VARYING CHARGE BASIS: $51 MILLION SYSTEM COST (1978 Sample Data, IDA Cost Allocation Model)

What Table 12 and Figure 11 also show is what would be the case if AUTODIN utilization *did not* respond to changes in the charge basis. The larger the indicated change, the less likely it is that the affected agency would not respond. Actually, the cost-allocations computer program can be used to calculate the no-response budget consequences of any set of rates and charges. By identifying the agencies that would be impacted, it can provide DCA with an indication of agencies that need to be studied in more detail, or whose estimates of usage and connections under a proposed rate change need to be analyzed carefully.

It is possible also to present hypothetical AUTODIN backbone cost allocations down to OSRI detail. We have not done so in the study, but if the kind of analysis suggested by the previous sections on demand is to take place, this is what should be done by DCA. Communications needs and likely responses make sense in terms of kinds of activities, not over whole agencies. That is to say, a central supply activity of the Air Force is likely to have more in common regarding AUTODIN demand with a similar activity in the Army than it does with a Tactical Air Forces Command Headquarters perhaps located at the same installation as the Air Force Supply Unit.

VIII. IMPLEMENTATION AND EFFICIENCY CONSIDERATIONS

The conflict between equity and efficiency in allocating AUTODIN costs was discussed in detail in the IDA study which preceded this effort.[1] In recommending that AUTODIN common costs be allocated to agencies in large part based upon the volume of usage, weighted by "prices", it was recognized that a new element of distortion was being introduced into the cost allocation system. Since for most foreseeable levels of AUTODIN demand, additional messages would not add to the "backbone" cost, the appropriate marginal cost and thus the appropriate price could only be zero. The user choosing whether or not to send a message would make the economically efficient choice if he treated messages as free. Within the limits of system capacity, and considering only the backbone cost, additional access connections should also be priced at zero. Under the current system, access involves substantial charges to the using agency. Thus the choice process for access lines is also distorted by positive prices--access should also be free.

How to minimize the effect of this distortion constitutes a problem for those setting rates for usage and volume. The effort of this study has been directed not at the rate setting problem, but at the means of applying the rates, once determined, to allocate costs. However, that same mechanism can provide the data which are needed to devise policies to minimize distortion. To do so one would want to select "second best" connectivity and usage prices that fully allocate cost and produce the same relative distortion in the number of connections and the volume

[1] Beazer, *et al.*, IDA S-487, *op. cit.*

of usage. What one needs for this purpose is some idea of the price elasticities and cross elasticities of demand for access and usage.[1] The data collected in the process of usage billing, with new access and usage prices, will provide the first quantitative information on such demand functions.

Some idea of the shape of total and individual user demand functions (the sort of data we "invented" in Section VII above) could be obtained by comparing the quantities of connections and usage under the current connectivity-only pricing scheme with results after the proposed change. In this respect it is probably imperative that additional data be collected on a user-by-user basis before any new rate scheme is implemented in order to have a more reliable base point. Since the current DCA budget process requires that planning rates be published to users as much as 18 months in advance of the relevant budget year, the first usage sample may be obtainable only during the year preceding usage-pricing implementation but after the announcement of the rates. The "announcement effect"[2] could cause the adjustment to take place in two steps which would give DCA an early indication of any impending shortfall or over-collection of backbone charges.

The changes in usage and connections occurring in the year before the new rates take place *could* give an indication of the direction and magnitude of the response to the rate changes. *Could* is emphasized, since only subsequent experiences after rates are implemented can confirm hypotheses developed from analyzing the data. Some effects may take years to work out.

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[1] A seminal reference to second-best pricing is W.S. Baumol and D.F. Bradford, "Optimal Departures from Marginal Cost Pricing," *American Economic Review*, June, 1970.

[2] An example would be the announcement of a material's price increase by suppliers to take effect at a later date. This provides producers with an opportunity to add to inventories now, thus increasing current sales for suppliers--an announcement effect opposite to the responses to the actual increase.

There are some procedural steps which DCA can take to minimize any new distorting effects of allocating cost on a usage basis. At the risk of stating the obvious, we will mention them for completeness. One possible step has been ruled out, and that is eliminating the cost allocation process entirely, letting AUTODIN be a DoD overhead cost paid out of appropriations directly to DCA, with access controlled solely on administratively determined need. While this might be sensible for AUTODIN backbone, it does not apply to other common user systems such as AUTOVON and future systems such as AUTODIN II, or indeed to the whole AUTODIN activity, where marginal costs of additional service *are not* zero.

However, it remains true that decisions at the level of message originators on whether or not to use an existing AUTODIN access for a particular communication cannot have any cost consequences--for the AUTODIN backbone cost that is being allocated. Therefore, agency and system managers do not want such lower level managers to treat AUTODIN rates as prices in the ordinary sense. The form in which the cost allocation "billing" is computed suggests that prices (rates) times usage drives cost. While this tells us how the AUTODIN system's "benefit" is distributed and what an equitable allocation should be, it is information that can only be properly interpreted by managers with a system overview responsibility.

In the preceding discussion and in our recommendations, we have tacitly assumed that decision makers at the uniformed services major command level consider the overall budget impact of their decisions about allocating resources for communications. In short, it is assumed that they understand the rationale behind user charges for AUTODIN and would not make decisions that reduce their AUTODIN budgets at the expense of increased total defense communications cost. To the extent this is not true, the managers' actions could

introduce more serious usage distortions since they make major alternations in system configuration.

One can suggest that DCA urge the agency managers to avoid equating AUTODIN rates and prices and adopting strategies to minimize agency budgets that can only be self-defeating in the long run. This is a managerial and educational effort to which this report can perhaps contribute.

An alternative would be to adopt some other procedure than concurrent billing. By concurrent billing we mean a procedure by which the using agencies reimburse the CSIF each month based on *actual* activity in the prior month. The number and speed of access lines connected, times the appropriate charge, plus the number of line blocks in each category, times the appropriate rate, would yield a total bill for the month in dollars. For any sub-unit this could vary from month to month, depending upon its activity. Such a procedure makes a comparison between the budgeted spending rate for AUTODIN and the actual spending rate not only possible, but likely, and clearly will be conducive to efforts to match budget and actual cost by limiting AUTODIN usage--economically speaking a wrong response from a system viewpoint.

One could deal with this partly by computing an annual budget on the basis of prior year usage and billing each month on the basis of one-twelfth of the total. While more compatible with the economic logic of our prior study supporting usage charges, adoption of this strategy would involve changing budget procedures and raise some questions about the use of samples in cost allocation. The chief merit of such a procedure, however, would be that it would largely eliminate the problem of forecasting demand. But inasmuch as allocations of cost would be collected regardless of budget year user behavior, the whole process of adjustment would take place in the negotiation over budget formulation. It would be difficult

to counter the argument for a reduced AUTODIN budget from a using agency that had been allocated an AUTODIN cost share on the basis of last year's usage and now could show a specific plan for considerably reduced activity in the budget year.

Whether to accept the risk of undercollection owing to forecasting errors inherent in concurrent billing under changing rates, or to undertake the administrative wrangle of changing budget procedures to permit enforceable fixed annual allocations, is already DCA's decision. Considerations not thought germane to the study could well be dominating. However, on pragmatic grounds, it should be noted that the forecasting problem, given some attention to analysis of data, should diminish considerably after the first year or two of usage-sensitive pricing, which argues for concurrent billing. Furthermore, any future billing system employing usage charges where traditional marginal cost pricing is appropriate should be concurrent, so that fairly low-cost experience with the mechanics of such billing for AUTODIN could be justified on its carry-over value.

IX. CONCLUSIONS AND RECOMMENDATIONS

Having demonstrated the feasibility of collecting and processing the data for billing AUTODIN users[1] for service based upon prices for connectivity and for usage, the principal study recommendation is that the usage-sensitive costing scheme conceptualized in IDA Study S-487[2] is ready for implementation. While not a part of the study charge, it appears appropriate to the authors to close the report with some caveats that should be borne in mind if and when usage-sensitive pricing is implemented.

The two arguments for such a scheme were on the basis of improving "equity" as perceived by peacetime users and increasing efficienty of the peacetime network. An "equitable" distribution of costs was one defined as payments proportioned to benefits as viewed by users. The argument for this is fairly straightforward until one introduces the crisis or wartime emergency use of the network. One can argue, as did several senior refined military officers and former government officials with top-level command and communications experience who informally reviewed this and the earlier study, that the choices made at operating level in response to prices for routine non-crisis communications could lead to degradation of the system's capability to respond in its primary role of command and control in response to crises. Since the charge of neither study included examining or evaluating this primary AUTODIN C^3 function, the authors can only acknowledge that such operational considerations clearly ought to override "equity"

[1]See Appendices A-D for procedure descriptions.

[2]See Appendix E for a reprint of the basic theoretical discussion from S-487.

matters where there is substantive conflict. The result will be, of course, that the system will be less than "efficient" in the sense used in the studies.

A less serious caveat has to do with the expected efficienty effects as they tend to lower communications costs. Such effects are indirect and the savings are not necessarily realized as AUTODIN savings. For example, shifting a portion of cost recovery to a usage basis permits connectivity fees to be reduced. In some cases, this may induce potential users previously connected by off-AUTODIN private lines to eliminate these leases in favor of arranging connection through AUTODIN. The savings in overall communication outlays will appear either as a reduction in the communications budget or an improvement in effectiveness procured by using the savings to increase expenditures on some other good or service. In either event, the financial managers at DCA will not necessarily know of this effect which the rate change has caused. While not a part of the charge of the study, the authors must use this instance to note that attempts to improve economic efficiency that deal separately with AUTODIN or AUTOVON or any other sub-part of total Defense Communications may well result in "incorrect sub-optimizations." While dealing as we have with various sub-parts is not likely to make things worse, economic analyses that can consider the wider range of substitute and complementary services that are available for communication are more likely to uncover savings and efficiencies for DoD.